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Some T_2 Terrace Soils of Peninsular Malaysia: I. Micromorphology, Genesis and Classification

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RINGKASAN

18 profil yang terdiri daripada 14 siri tanah teres T_2 di Semenanjung Malaysia telah dikaji. Tanah-tanah ini berasal daripada bahan aluvium campuran yang berumur Holosen. Kebanyakan tanah itu dikelaskan sebagai Inseptisol. Yang lain-lainnya pula dikelaskan sebagai Entisol, Ultisol dan Alfisol. Kajian ini menunjukkan tanah-tanah tersebut berada sama ada di peringkat luluhawa baharu atau pertengahan. Taburan pertalian k/h ialah gefurik di dalam famili berpasir, gefurik dan/atau kitonik di dalam famili berlom kasar, dan porpirik di dalam famili berlom halus dan berlempung. Adalah diketahui bahawa pitolis lebih sering dijumpai di pantai timur daripada di pantai berat.

SUMMARY

18 profiles belonging to 14 soil series of the T_2 terrace soils of Peninsular Malaysia were studied. The soils are derived from alluvial materials of mixed origin of Holocene age. They are mainly Inceptisols. Others are classified as Entisols, Ultisols and Alfisols. The study indicates that the soils are either in the recent or intermediate stage of weathering. The c/f related distribution is gefuric in the sandy families, gefuric and/or chitonic in the coarse loamy families, and porphyric in the fine loamy and the clayey families. It is found that phytoliths are more common in the east than in the west coast of the peninsula.

INTRODUCTION

About 40% of the land surface of Peninsular Malaysia is hilly or mountainous (Gopinanthan and Paramananthan, 1979). Most of the flat areas occur in the alluvial plains, which are either marine or riverine in origin. Riverine alluvial deposits occur at three levels, namely T_3, T_2 and T_1, which are respectively referred to as high, intermediate and low terraces (Gopinanthan, 1968). Of particular interest are the soils on T_2 terraces because of their spatial distribution.

The objective of this study is to provide information for a complete taxonomic classification of T_2 terrace soils as well as to study their genesis and micromorphology.

MATERIALS AND METHODS

18 pedons belonging to 14 soil series were selected for the study. These are the soils of Nangka (1, 9), Kampung Pusu (2), Bukit Tuku (3), Kerayong (4, 12), Cherang Hangus (5), Sungai Buloh (7, 8, 13), Lintang (6), Subang (10), Sogomana (11), Rasau (14), Napai (15), Chuping (17) and Holyrood (18). The soils are named approximating as much as possible the definition proposed by the Department of Agriculture (Paramananthan, 1981).

The soils were sampled from many areas *(Fig. 1)*, where T_2 terrace soils are known to be found. These are around the vicinity of Pasir Mas, Kelantan (1, 2, 3, 4, 5), Kuala Trengganu (6), Batu Pahat (8, 9), Sungai Buloh, Selangor (7), Lower Perak (10, 11, 12, 13, 14), Pokok Sena, Kedah (15), Pauh, Perlis (16) and Langkawi (17, 18).

Types of samples taken are:–

1. Bulk samples for routine, physico-chemical and mineralogical analyses.
2. Undistrubed samples in a Kubiena box for micromorphological analyses.
3. Core samples for physical analyses.

Analytical procedures are as follows: granulometric analysis was carried out by successive sedimentation. pH was determined both in water

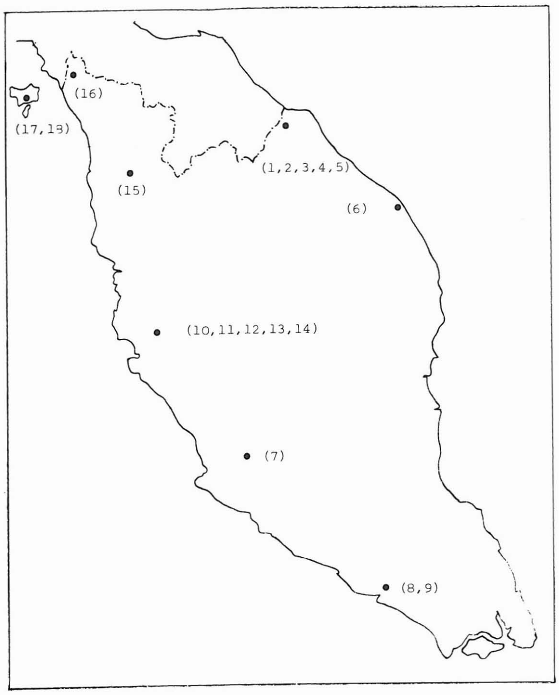

Fig. 1. A map of Peninsular Malaysia showing the position of sampling (dot denotes the area of sampling and number denotes pedon).

and 1N KCl after 1 day of equilibration. CEC was determined in 1N NH_4OAc buffered at pH 7 and in 1N NH_4Cl solution. KCl acidity (Al + H) was determined by the method of Yuan (1959). Extractable acidity was estimated by KCl-TEA buffered at pH 8.2. Organic carbon was determined by the Walkley-Black Method (Allison, 1965) and nitrogen was determined by the method of Bremner (1965). Free iron oxide was estimated by the dithionite citrate bicarbonate (DCB) method of Mehra and Jackson (1960). Base saturation is the sum of bases expressed as % of CEC (NH_4OAC), while Al saturation is the Al expressed as % of Al plus bases. Micromorphological description was done following the proposal of Stoops (1978). Analytical data are given in the Appendix.

RESULT AND DISCUSSIONS

1. General consideration

1.1 Climate

Peninsular Malaysia is characterised by high rainfall and uniformly high temperature. The moisture regime of the well drained areas is either udic or perudic. The rainfall is relatively higher in the south than in the north of the peninsula, and most of Johor has a perudic moisture regime. The northern states of Kedah and Perlis have an udic moisture regime, with spotted places approaching ustic. The slight variation in climate may have some influence on the genesis of the soils.

Soil temperature can roughly be estimated by adding 2.5°C to the air temperature (Tavernier – *private communication*). Using this assumption, it is found that the soil temperature (at 50 cm depth) in the areas under study varies from 28°C to 30°C. The temperature regime is isohyperthermic throughout the country as MSTT-MWST is less than 5°C (MSST = mean summer soil temperature, MWST = mean winter soil temperature).

1.2 Geology

The most important rock type in the peninsula is granite, occupying about 50% of the land surface (Yeh, 1968). Other rock types are limestone, sandstone, shale, schist and basic igneous rocks (Gobbett, 1972; Yin and Shu, 1973). The main rivers controlling the drainage pattern of the peninsula are the Sg. Pahang (420 km), Sg. Perak (350 km) and Sg. Kelantan (280 km). Over the years, the mouth of the rivers have shifted according to the direction of the prevalent current. For instance, Sg. Kelantan has moved 35 km toward northwest of the former river (Tjia, 1970; Tjia, 1973).

1.3 Sea Level Changes and Terrace Formation

Evidence for the change in sea level in the Quaternary is abundant. The presence of wave-cut notches (Hodgkin, 1970) and marine beach deposits (Nossin, 1961; 1964) are evidence for Quaternary sea level change. Evidence of a late Quaternary change in sea level is widespread in the Indonesia Archipelago in the form of raised coral reefs and raised beach terraces (Haile, 1970). Even prograding streams have been interpreted by Tjia (1970) as evidence of the fall in sea level.

Biswas (1973) found some evidence of changes in sea level from punch cores off the east coast of Peninsular Malaysia. Lithologic changes combined with foraminiferal and spore-pollen data indicate shallowing of extensive areas of the South China Sea. From the available data so far, Tjia (1973) proposed that the highest sea level in the Quaternary was about 30–50 m above and the lowest 100 m below the present sea level. It is assumed that the Quaternary changes in sea level are at the origin of the terrace formation.

1.4 Characteristics of Young Alluvium

The deposits forming the T_2 terraces are unconsolidated deposits of sand and gravel with some clay and peat. These deposits, which can be equated to Young Alluvium (Subrecent Alluvium), are of Holocene age (<10,000 years). The Young Alluvium is characterised by unweathered or slightly weathered clasts and soils developed from it are commonly less than 2 m deep (Stauffer, 1973). The Young Alluvium of the Kinta Valley contains an abundant amount of sedimentary structures of fluvial origin (Sivam, 1969). Sivam (1968) found the age of this deposit to be about 3000 years.

2. Geographical Distribution

Physiographically, T_2 terrace soils are found mainly at 20–30 m elevation, in areas adjacent to coastal plains, concentrated along major rivers. Up to this moment, over 25 soil series have been defined and characterised by the Department of Agriculture (Paramananthan, 1980; 1981).

A quick look at the literature indicates that the most common T_2 terrace soils are apparently Sogomana, Nangka, Rasau, Holyrood, Lintang, Kerayong and Sungai Buloh Series, which are found in the alluvial plains of Kelantan, Trengganu, Pahang and Perak (Leamy and Panton, 1965; Law, 1968; Gopinathan, 1968). Soils of Cherang Hangus, Gong Chenak, Bukit Tuku and Kampung Pusu Series occur almost exclusively in Kelantan Plains (Arnott, 1957; Law, 1968). Other soils such as the soils of Chuping and Napai series are respectively found in Perlis and Kedah.

3. Characterisation of the soils (Table 1)

3.1 Nangka Series (1, 9)

These soils are characterised in the field by a loamy sand top soil underlain by sandy loam. The structures are weak, medium, subangular blocky and the consistence is friable.

The microstructure of this subsoil is cavitied, with channels and vughs as the main type of pores. The coarse materials are dominated by quartz. The fine materials, which are brown in colour, have undifferentiated b-fabric (1) or dotted scally b-fabric (9). The undifferentiated b-fabric is the result of coating by gibbsite (Stopps, 1978). The c/f related distribution is chitonic and/or gefuric. Cavitied microstructure shows that the drainage is very good.

Physico-chemical and micromorphological studies, and field observations indicate that the soil is Typic Dystropept (Table 2). According

TABLE 1
Field characteristics of T2 terrace soils of Peninsular Malaysia
(+ colour and texture at 50 cm depth).

SERIES	COLOUR+		TEXTURE+	STRUCTURE	CONSISTENCE	DRAINAGE
Nangka (1)	10YR	(6/4)	sandy loam	weak	friable	well drained
Kampung Pusu (2)	2.5YR	(7/3)	clay loam	moderate	firm	poor
Bukit Tuku (3)	2.5Y	(6/4)	clay loam	moderate	firm	imperfect
Kerayong (4)	10YR	(6/6)	clay	moderate	firm	moderate
Cherang Hangus (5)	N7/		clay	moderate	plastic	poor
Lintang (6)	10YR	(5/6)	sandy loam	weak	friable	well drained
Sungai Buloh (7)	10YR	(5/4)	coarse sand	structureless	loose	excessive
Sungai Buloh (8)	10YR	(7/6)	coarse loamy sand	weak	friable	excessive
Nangka (9)	10YR	(6/4)	coarse loamy sand	moderate	friable	well drained
Subang (10)	N7/		fine loamy sand	structureless	firm	poor
Sogomana (11)	N7/		silty clay loam	weak	firm	poor
Kerayong (12)	10YR	(5/4)	clay loam	moderate	firm	moderate
Sungai Buloh (13)	10YR	(5/4)	loamy coarse sand	weak	friable	excessive
Rasau (14)	2.5Y	(8/3)	loam	moderate	firm	well drained
Napai (15)	5YR	(5/8)	sandy clay	weak	firm	well drained
Chuping (16)	10YR	(6/6)	clay loam	weak	friable	imperfect
Awang (17)	10YR	(6/1)	sandy clay loam	weak	firm	imperfect
Holyrood (18)	7.5YR	(6/5)	sandy clay loam	weak	friable	well drained

TABLE 2
The classification of T_2 terrace soils of Peninsular Malaysia

SERIES	USDA (1975)	FAO/UNESCO (1974)
Nangka (1)	Typic Dystropepts	Dystric Cambisols
Kampung Pusu (2)	Aeric Tripaquepts	Dystric Gleysols
Bukit Tuku (3)	Plinthaquic Dystropepts	Gleyic Cambisols
Kerayong (4)	Oxic Dystropepts	Gleyic Cambisols
Cherang Hangus (5)	Typic Tropaquepts	Dystric Gleysols
Lintang (6)	Oxic Dystropepts	Dystric Cambisols
Sungai Buloh (7)	Typic Quartzipamments	Ferrallic Arenosols
Sungai Buloh (8)	Orthoxic Quartzipsamments	Ferrallic Arenosols
Nangka (9)	Fluventic-Oxic Dystropepts	Dystric Cambisols
Subang (10)	Typic Tropaquents	Dystric Gleysols
Sogomana (11)	Typic Tropaquults	Gleyic Acrisols
Kerayong (12)	Oxic Dystropepts	Dystric Cambisols
Sungai Buloh (13)	Typic Quartzipsamments	Ferrallic Arenosols
Rasau (14)	Oxic Dystropepts	Dystric Cambisols
Napai (15)	Typic Paleudults	Dystric Nitosols
Chuping (16)	Aquic Tropudalfs	Gleyic Luvisols
Awang (17)	Aquic-Oxic Dystropepts	Gleyic Cambisols
Holyrood (18)	Typic Paleudults	Dystric Nitosols

to FAO, the soil can be classified as a Dystric Cambisol.

3.2 Kampung Pusu Series (2)
These soils are poorly drained. They are recognised in the field by the clay texture and reddish yellow mottles at depth. The structures are moderate, medium and fine subangular, and the consistence is firm (Table 1).

The microstructure is cavitied and the pores are mainly vughs. Quartz is the dominant mineral in the coarse fraction. The fine materials, which are brown in colour, have a scally and weakly porofibrous b-fabric. The c/f related distribution is single-spaced porphyric. Some Fe nodules are present in the matrix, indicating moisture saturation. Clay cutans were not seen, although in the field they were described as present. As such, the B_2 horizon of this profile is rather a cambic horizon.

Taxonomically, this soil can be classified as fine loamy mixed, acid, isohyperthermic Aeric Tropaquept (Table 2). It can be classified as a Dystric Gleysol in the FAO/UNESCO Legend.

3.3 Bukit Tuku Series (3)
These soils are characterised by the presence of coarse, prominent and sharp mottles at depth. These red mottles are plinthite, as it hardens on drying.

The microstructure is cavitied with channel as the most common type of pores. The coarse materials are dominated by quartz, tourmaline and zircon. The gray clay materials have a dotted scally b-fabric. The c/f related distribution is single-spaced porphyric. Some decomposed root fragments and phytoliths are present in the B_{21} horizon. The presence of Fe-Mn nodules shows that translocation and deposition in an oxido-reduction environment has taken place. Some clay cutans were observed, but they do not represent the 1% required for an argillic horizon.

According to Soil Taxonomy (USDA, 1975), this soil should be classified as Plinthaquic Dystropept, but a plinthaquic subgroup does not exist at the moment. To accomodate this subgroup in Soil Taxonomy, the definition of Typic Dystropepts should have an additional criteria:

i. "Have less than 5% plinthite (by volume) in all subhorizons within 1.5m of the soil surface".

Plinthaquic Dystropepts are therefore like Typic Dystropepts except of a and i.

3.4 Kerayong Series (4, 12)

These soils are moderately well drained. They have a clayey texture. The structures are moderate, medium, subangular blocky and the consistence is firm.

The microstructure is cavitied (4, 12) and occasionally fissured (4). Fissured microstructure is usually associated with clayey soils undergoing successive processes of drying and wetting. Fissured microstructure is also related to 2:1 clays, which are present in these soils. Quartz and, occasionally muscovite are present in the coarse materials. Weathering of this mica liberates important amounts of K necessary for plant growth.

The b-fabric is parallel fibrous (4) and strong scally and weak granofibrous (12), while the c/f related distribution is open porphyric (4) and single-spaced porphyric (12). Phytoliths are present in the B_{21} horizon (4). Clay cutans, which were seen in the field, could not be regarded as illuviation cutans as they could not be identified in the thin section. Soils of Kerayong Series can be classified as Oxic Dystropepts or Cambisols (Table 2).

3.5 Cherang Hangus Series (5)

The soils are characterised in the field by the presence of a light gray clay, showing coarse, angular blocky structures and sticky consistence. Reddish yellow mottles are present in the B horizons.

The microstructure is cavitied, with channels as the main type of pores. Some muscovite and biotite are present, suggesting a slow rate of weathering. The b-fabric of the soil is parallel fibrous, while the c/f related distribution is open porphyric. Phytoliths and Fe nodules are present. The presence of argillans is rare. The soil is classified as Typic Tropaquept or Dystric Gleysol (Table 2).

3.6 Lintang Series (6)

This is a coarse loamy soil. It is identified by a dark grayish brown sandy top soil, overlying a yellowish brown subsoil. The structures are weak, coarse, subangular blocky, while the consistence is friable.

The microstructure is cavitied. The main type of pores are channels and vughs. Quartz and tourmaline, in order of decreasing importance, are the dominant minerals in the coarse fraction. In the fine materials, stippled brown clay materials, with dotted scally b-fabric are present. The c/f related distribution is gefuric and enaulic to porphyric. Some partially humified opaque tissue fragments are present in the matrix.

Pedofeatures seen in the soil are clay cutans and phytoliths. The presence of cutans is consistent with field observation. The cutans, however, represent less than 1% and thus do not meet the requirement of an argillic horizon. This soil is therefore classified as Oxic Dystropept or Dystric Cambisol.

3.7 Sungai Buloh (7, 8, 13)

Soils of Sungai Buloh series are sandy in nature and lack pedogenic development. The soils are chiefly structureless, with some very coarse, very weak, subangular blocky aggregates. The consistence is loose and the drainage is somewhat excessive.

The microstructure of this soil is also cavitied. The pores are mainly vughs. The coarse materials are mainly quartz. The fine materials are composed of gray (8) or brown clay (13) and the b-fabric is undifferentiated. The c/f related distribution is gefuric and enaulic. Some dark to opaque tissue fragments are present at random in the matrix.

Taxonomically, this soil can be classified as Typic (7, 13) or Orthoxic (8) Quartzipsamment. According to FAO, it can be classified as Ferrallic Arenosol.

3.8 Subang Series (10)

Subang Series is a loamy sand, found in depressions. It is identified in the field by a sandy loam top soil underlain by a light grey loamy sand. At depth, the soil is structureless.

The microstructure is cavitied. Quartz in the coarse materials, is subangular in shape, indicating some distance of transportation has taken place before final deposition. Weatherable minerals, such as biotite and feldspar are present. Their presence indicates the recent nature of the soil. This soil is in fact a Tropaquent.

The fine materials are reddish clay, with weakly granofibrous b-bfabric. The red colouration is the result of staining by Fe oxides and/or hydroxides released from the weathering of biotite. Some strong continuous, orientated ferriargillans are present in the pores. These cutans are probably transported. However, the amount of cutans is less than 1% and therefore does not meet the requirement of an argillic horizon.

3.9 Sogomana Series (11)

This soils is clayey. A lower clay content in the surface horizon is compensated by a very high silt content. Detailed investigation of the textural profile suggests the presence of lithologic discontinuities throughout the profile.

The soil has a cavitied and fissured, and occasionally, irregular jointed microstructure at depth. The pores are mainly vughs. The coarse materials are composed of quartz and muscovite, while the fine materials consist of dotted, yellowish gray clay materials. The b-fabric is dotted scally and very broad and thin cross fibrous. The c/f related distribution is open porphyric.

Irregular soil nodules (2–3 mm ϕ), which are composed of small nodules (< 100 um) in different stages of formation, are present in the B_{21t}. Yellowish brown ferriargillans, with strong, continuous orientation, are present in the pores. The presence of thin patchy cutans, which were observed in the field, are therefore confirmed. This is a clear indication of clay translocation in the profile. Field observations and laboratory analyses show that the soil is a Typic Tropaquult or Gleyic Gleysol.

3.10 Rasau Series (14)

The soil is recognised in the field by its loamy texture and pale colour at depth. The structures are moderate, medium and fine subangular block; and the consistence is friable.

The microstructure is also cavitied. Channel is the main type of pore. In the coarse materials, quartz, zircon and tourmaline are present. The fine materials consist of dusty grey clay, with undifferentiated b-fabric. The c/f related distribution is gefuric to close porphyric. The soil can be classified as Oxic Dystropept.

3.11 Napai Series (15)

Soils of Napai Series are developed on reworked lateritic materials from shale. Petroplinthite is present in the form of loose penetrable concretions, usually at shallow depth. The structure of the top soil is weak to moderate, medium, subangular blocky. Thin patchy cutans were seen in the field. The study shows that the soil is a member of coarse loamy over clayey-skeletal, kaolinitic, isohyperthermic Typic Paleudults.

3.12 Chuping Series (16)

This soil is developed on reworked lateritic materials, resting on limestone of Chuping Formation. The top soil is a light yellowish brown sandy loam overlying and brownish yellow sandy clay loam.

Thin patchy cutans characterise the B horizons. Distinct, brownish yellow mottles appear in the B_{21t} . Petroplinthite sometimes appear at shallow depth. Base saturation is high, being 100% at depth. This soil is therefore classified as coarse loamy over fine loamy-skeletal, mixed, isohyperthermic, Aquic Tropudalf or Gleyic Luvisol.

3.13 Awang Series (17)

This soil is derived from parent material originated from tourmaline rich granite. The top soil is a light gray coarse sand. This is underlain by a light brownish gray loamy sand. The colour becomes lighter with depth. Yellowish brown mottles appear in B_{22} showing that the drainage conditions are somewhat impeded. This soil can be classified as Aquic-Oxic Dystropept. A thin section for this soil is not available.

3.14 Holyrood Series (18)

Thin continuous cutans characterise the B_2 horizon. The top soil is brown sandy clay loam, overlying a light brown sandy clay loam. The colour becomes redder with depth, due to the increase of Fe oxides with depth. On available data, this soil can be classified as Typic Paleudult. A thin section for this soil is not available. Thus it is not possible to prove the presence of cutans micromorphologically. There is an increase of clay content with depth. The presence of cutans and the increase of clay with depth seems to indicate that the soil is a Paleudult.

4. Genesis of T_2 Terrace Soils

4.1 Influence of Soil Forming Factors

It is apparent that the most important factors affecting the soil forming processes of T_2 terrace soils are parent material and climate. It is known that the most important rock unit in the country is granite, occupying about 50% of the total land surface (Yeh, 1968). These granite bodies form mountain ranges in the central and the eastern part of the peninsula.

The chief rivers, which control the drainage pattern of the peninsula, originate and draw their water from those mountains. On their way to the sea, the rivers cut through other rock types and carry along with them deposits of varying composition. The nature of the deposits vary from clayey and silty to sandy materials. There is evidence to suggest that the textural and the mineralogical composition of the alluvial deposits are, for an important part, influenced by the granite mineralogy. The dominance of subangular tourmaline in the heavy mineral fraction of the VFS (Pettijohn, 1957) further justifies the above statement.

However, some of the soils on T_2 terrace are silty and clayey. These sediments are probably not derived solely from granite. THere are two possibilities with regard to the origin of the parent materials of these silty clayey soils:

1. The parent material is originated from shale, phyllite, schist or other fine grained sedimentary or metamorphic rock.
2. The parent materials are deposited in a low energy environment, characterised by fine sediments (Reineck and Singh, 1973).

The mouths of rivers in Peninsular Malaysia shift according to the direction of the prevalent long shore currents. The rivers in Kelantan and Trengganu move northwards, while the rivers in Kedah and Perlis move southwards (Tjia, 1973). The change in the course of these rivers may change the composition of the deposits of the area because it influences the environment of deposition. This may be at the origin of lithologic discontinuities and stratification of the sediments (see 5.1).

Coupled with parent material, climate and time control the type and stage of weathering. Physico-chemical weathering of the deposits takes place immediately after they are exposed to the atmosphere. With an annual rainfall exceeding 2,000 mm in most parts of the country and a mean annual temperature of about 27°C (Dale, 1963), chemical weathering is intensive.

Topography and vegetation are playing a modifying role in this process of ferrallitic weathering. In the well drained areas, with important removal of silica and bases, weatherable minerals are being transformed into kaolinite and/or sesquioxides, and in some cases, the soils are practically devoid of weatherable minerals. On the other hand, where the drainage is impeded, feldspar, muscovite and even biotite survive secondary transformation. The best example of the latter is the Subang Series (10).

4.2 Ferrallitization

Ferralitization is the chief soil forming process in the humid tropics (Sys, 1979). This process is characterized by the dominance of 1:1 clay mineral and/or sesquioxides, particularly gibbsite. As evidenced byXRD and thermal analyses (Shamshuddin and Tessens, unpublished the studied soils have those minerals in the clay fraction.

Leaching and subsequently weathering is somewhat related to the textural composition of the original alluvial deposits. Thus in sandy materials, leaching and weathering are so intense that primary minerals or even kaolinite may transform to gibbsite. Such transformation is noted in the soils of the Sungai Buloh Series (7), where gibbsite exceeds kaolinite in the clay fraction. On the contrary, in the loamy and the clayey materials, where leaching and weathering are expected to be less intense, kaolinite dominates over gibbsite.

4.3 Clay Translocation

In most cases, cutans were not seen in the thin sections. The ones which contain cutans can not be considered as having argillic horizons as the % of cutans is less than 1%. As such, it is considered that no major translocation of clay has occurred yet. In general, the soils contain a cambic horizon.

4.4 Weathering Stage

Weathering stage of soils can be defined by various criteria. Among the criteria used are the silt/clay ratio (Van Wambeke, 1962) and mineralogy of the clay fraction (Jackson and Sherman, 1953). Stage of weathering can also be defined by the proposal of Sys (1979) or by the charge characteristics of the soils (Tessens and Shamshuddin, 1982).

In spite of the limitation, due to the problem of changing lithology, silt/clay ratio can be used successfully to obtain the stage of weathering of the studied soils, as follows:–

1. Recent stage – silt/clay ratio is more than 1.
2. Intermediate stage – silt/clay ratio is 1–0.2.
3. Advanced stage – silt/clay ratio is less than 0.2.

The studied soils can be grouped accordingly (Table 3).

It is seen that most of the soils are either in the recent or in the intermediate stage of weathering. The soils of Subang Series (10) give the highest value (3.68), implying that they are the least weathered soils. Thin-section study indicated that the soil contains feldspar, muscovite and biotite, consistent with the high silt/clay ratio. On the other hand, the most weathered of the soils are the Napai (15) and the Holyrood Series (18); these soils are Paleudults.

TABLE 3
Stage of weathering of T2 terrace soils according to silt/clay ratio

RECENT	INTERMEDIATE	
Nangka (1)	Kg. Pusu (2)	Lintang (6)
Bt. Tuku (3)	Keryong (4)	Nangka (9)
Subang (10)	Chg. Hangus (5)	Napai (15)
Sogomana (11)	Chuping (16)	Holyrood (18)
Kerayong (12)	Awang (17)	
Rasau (14)		

TABLE 4
Stages of ferrallitic weathering

RECENT	INTERMEDIARY
Sungai Buloh (7,8,13)	Nangka (1,9)
Subang (10)	Kampung Pusu (2)
Awang (17)	Bukit Tuku (3)
	Kerayong (4)
	Cherang Hangus (5)
	Lintang (6)
	Sogomana (11)
	Rasau (14)
	Napai (15)
	Chuping (16)
	Holyrood (18)

Feldspar and biotite are minerals in the recent stage of weathering (Jackson and Sherman 1953). Muscovite, vermiculite and montmorillonite are minerals in the intermediate stage while kaolinite and sesquioxides are minerals in the advanced stage of weathering. Based on this consideration, it is found that the soils of Subang (10) and Awang Series (17) fall under recent stage of weathering; these soils contain biotite and feldspar. Soils in the intermediate stage of weathering are the Nangka (1), Kampung Pusu (2), Bukit Tuku (3), Kerayong (4, 12), Cherang Hangus (15), Sogomana (11), Napai (15), Chuping (16) and Holyrood Series (18). Soils of Lintang (6) and Sungai Buloh Series (7, 8, 13) seem to fit into the advanced stage of weathering.

According to the stages of ferrallitic weathering of Sys (1979), soils of Subang (10) and Awang Series (17), which contain weatherable minerals, are in the recent stage (Table 4). Soils of Sungai Buloh Series (7, 8, 13) are difficult to put into the system, as they have no pedogenic development and dominated by kaolinite and/or gibbsite. Taxonomically, they are classified as Entisols. In this study, the soils are included in the recent stage of ferrallitic weathering. Other soils, with cambic or argillic horizons, are included in the intermediary stage.

In all systems, it is supposed that the soil changes its properties on changing from recent to an advanced stage of weathering. This has a direct effect on the mineralogy and chemistry of the soil.

5. GENERAL DISCUSSION

5.1 Lithologic Discontinuities

In the Kerayong Series (4), there appears to be an increase of clay in the B_2; the increase of clay from A_p is 6.3%. This definitely does not meet the requirement of an argillic horizon. An argillic horizon needs at least an increase of 8% for this clayey soil (USDA, 1975). The textural differentiation in the profile then is rather due to a change in the environment of sedimentation. This is expressed in the VFS/sand %. A change of VFS/sand % from 34.6% over 50.4% to 68.2% (A_p, B_{21} and B_{22} resp.) is an indication of the presence of several lithologic discontinuities throughout the profile.

Similarly, the VFS/sand % can be used to confirm the presence of lithologic discontinuities in the soils of Cherang Hangus (5), Subang (10), Sogomana (11), Kerayong (15) and Awang Series (17). Such discontinuities were not recognized in the field.

5.2 Micromorphology

5.2.1 Microstructure

It is noted for the soils in the sandy and coarse loamy family that the microstructure is cavitied. This is well illustrated by the soils of Sungai Buloh (8, 13), Lintang (6) and Nangka Series (1, 9). Likewise, the fine loamy family has a cavitied microstructure. Cavitied and occasionally fissured microstructures are found in the clayey soils. Such is the case for the soils of Kampung Pusu (2), Kerayong (4, 12), Cherang Hangus (5) and Sogomana Series (11).

Microstructure is related to the porosity of the soil. Cavitied microstructure is usually associated with high porosity, meaning that water can pass through easily.

5.2.2 Coarse Materials (>10 um)

Regardless of texture, the most common mineral in the coarse materials, in these soils, is quartz. These quartz grains vary in size from coarse to fine, with a subangular to angular shape. Roundness of the grains will, to a certain extent, provide information on the distance of transportation before final deposition takes place, as grains which have undergone a long distance of transportation are usually rounded.

Other minerals in the coarse materials are zircon and tourmaline. According to Pettijohn (1957), rounded tournaline and zircon originate from reworked sediments, while euhedral tourmaline and zircon originate from acid igneous rock. Most of the tourmaline and zircon in the studied soils are subangular in shape. This is an indication that the soil material is influenced by acid igneous rocks, transported over some distance.

5.2.3 Fine materials (<10 um)

The fine materials consist of clay minerals, varying in colour from grey to red. From the mineralogical studies, it is found that these materials are mainly kaolinite, 2:1 minerals and mixed layers. Beside these, there is also an important amount of gibbsite, especially in the sandy soils. The gibbsite coatings affect the b-fabric of the fine materials.

The undifferentiated b-fabric seen in the sandy soils is probably the result of gibbsite coating and/or masking of this sesquioxidic materials on the clay surfaces (Stoops, 1978; Eswaran *et al*, 1979). Under crossed polarizers, the fine materials are almost isotropic. The b-fabric of the clayey soils is either scally or fibrous or both. This type of b-fabric is present in the soils of Kampung Pusu (2), Kerayong (4) Cherang Hangus (5) and Sogomana Series (11).

5.2.4 C/F Related Distribution

The c/f related distribution of T_2 terrace soils depends for an important part on the textural composition of the soils. In the sandy family, the c/f related distribution are locally observed in these soils. This type of c/f related distribution is noted for the soils of Sungai Buloh Series (8, 13).

As the amount of clay in the soils increases, the c/f related distribution tends toward porphyric. In the coarse loamy family, such as Nangka (1) and Lintang (6), the c/f related distribution is gefuric and/or chitonic, tending toward porphyric. Soils of Bukit Tuku (3) and Rasau Series (14), which are fine loamy, have porphyric c/f related distribution. Gefuric c/f related distribution was found only occasionally in these soils. The c/f related distribution of the clayey soils, such as the Kampung Pusu (2), Kerayong (4, 12), Cherang Hangus (5) and Sogomana Series (11), is almost exclusively porphyric. Texture plays an important role in the formation of the name c/f related distribution. It is the clays that bind together and coat the coarse materials.

Related to classification, gefuric is common in Entisols. Among the gefuric, chitonic, enaulic and porphyric, the more developed profiles have at least two of these c/f types.

5.2.5 Clay Cutans

The consequence of physical translocation of clay mineral in the soil is the formation of an argillic horizon. One of the conditions for the formation of this horizon is minimal soil pedoturbation, in order to prevent the assimilation of the argillans into the matrix (Eswaran *et al.*, 1979). Formation of the argillans is a dispersion-deposition phenomenon (Eswaran and Sys, 1979). The subject of clay cutans is an important issue in this study, as clay cutans are an important parameter in soil classification.

In the field, all the clayey soils and some of the loamy soils were described as having thin patchy cutans. When these soils were examined under the microscope, clay cutans could not be identified, except occasionally in the soils of Bukit Tuku (3) and Lintang Series (6); only the soils of Sogomana Series (11) contain a sufficient amount of cutans. The soils of Kampung Pusu (2), Kerayong (4, 12) Cherang Hangus (5) and Rasau Series (14) do not show the presence of clay cutans.

The problem of cutans identification has also been discussed at length by Beinroth (1982) for soils of Puerto Rico. It was found that field observation of clay skins and their distinction from stress cutans is a serious difficulty in soils having clayey texture and kaolinitic mineralogy. For instance, an Oxic Tropohumult, which has been described as having many clay skins in the field, was found to contain only 2% cutans. On the other hand, another soil, which had been classified as Oxisol, contained 4% cutans. The unequivocal recognition of an argillic horizon as defined in

Soil Taxonomy poses serious problems in the soils of the humid tropics.

5.2.6 Phytoliths

These are opaline silica and therefore are isotopic under crossed polarizers. Under polarized light, phytoliths have characteristics of rectangular plant cells, with a rather high negative relief (Stoops, 1978). The XRD pattern resembles that of high temperature silica (crystobalite), with a strong reflection peak at 4A (Brown *et al.*, 1978). This peak was seen many times in the XRD diffractograms of the silt fraction. The soils that contain phytoliths are Lintang (6), Kerayong (4), Cherang Hangus (5) and Bukit Tuku Series (3). All of these soils are from the east coast of Peninsular Malaysia. Soils on T_2 terrace from the west coast appear to contain few or no phytoliths, as evidenced from the study of thin-sections.

CONCLUSION

Some T_2 terrace soils are found in Peninsular Malaysia. These soils are either in a recent or intermediate stage of weathering, shown by the silt/clay ratio and mineralogy. Most of the soils contain some cutans, but could not be regarded as illuviation cutans as the amount is less than 1% required for an argillic horizon. These soils are therefore classified as Inceptisols. The sandy soils lack pedogenic development and are classified as Entisols. Others are either Ultisols or Alfisols.

The change of clay content with depth is due to a change in the environment of sedimentation rather than clay illuviation. The presence of lithologic discontinuities in the profiles is shown by a change of the VFS/sand % ratio. The c/f related distribution of sandy soils is gefuric, while those of coarse loamy is gefuric and/or chitonic. The fine loamy and clayey soils have porphyric c/f related distribution. Phytoliths are more common in the east than the west coast of the peninsula.

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REFERENCES

ALLISON, L.E. (1965): Organic carbon by Walkley-Black Method. In: "Methods of Soil Analysis". Black, C.A. (Ed.). *Agronomy Monograph.* 9: 1367-1378.

ARNOTT, G.W. (1957): The Kelantan deficiency area. *Malays. Agric. J.* 40: 60-91.

BEINROTH, F.H. (1982): Some highly weathered soils of Puerto Rico, 1. Morphology, formation and classification. *Geoderma.* 27: 1–73.

BISWAS, B. 1973): Quaternary changes in sea level in South China Sea. *Bull. Geol. Soc. Malays.* 6: 229-256.

BREMNER, J.M. (1965): Total nitrogen. In: "Methods of Soil Analysis". Black, C.A. (Ed.). *Agronomy Monograph.* 9: 1149-1178.

BROWN, G., NEWMAN, A.C.D., RAYNER, J.H. and WEIR, A.H. (1978): The structure and chemistry of Soil Constituents". Greenland, D.J. and Hayes, M.H.B. (Eds.). New York. John Wiley and Sons. 29–78.

DALE, W.L. (1983): Surface temperature of Malaya. *J. Trop. Geog.* 17: 57-73.

ESWARAN, H. and SYS, C. (1979): Argillic horizon in LAC soils: formation and significance to classification. *Pedologie.* 2(2): 175–190.

ESWARAN, H. VAN WAMBEKE, A. and BEINROTH, F.H. (1979): A study of some highly weathered soils of Puerto Rico: Micromorphological properties. *Pedologie.* 29(2): 139–162.

FAO/UNESCO (1974): Soil Map of the World. Vol. 1. Legend. UNESCO, Paris.

GOBBETT, D.J. (1972): Geological Map of the Malay Peninsula. *Geol. Soc. Malays.*, Kuala Lumpur.

GOPINATHAN, B. (1968): Terrace and alluvial soils in West Malaysia. Proc. 3rd Malaysian Soil Conference. *Malaya. Soc. Soil Sci.*, Sarawak, pp. 45–50.

GOPINATHAN, B. and PARAMANANTHAN, S. (1979): Steepland soils in Peninsular Malaysia. Proc. Malaysian Seminar on Fertility and Management of Deforested Soils. *Soc. Agric., Sci. Sabah and Malays. Soc. Soil Sci.*, pp. 61–68.

HAILE, N.S. (1970): Radiocarbon dates of Holocene emergence and submergence in Tembelau and Bunguran Islands, Sunda Shelf, Indonesia. *Bull. Geol. Soc. Malays* 3: 135–137.

HODGKIN, E.P. (1970): Geomorphology and biological erosion of limestone coast in Malaysia. *Bull. Geol. Soc. Malays.* 3: 27-51.

JACKSON, M.L. and SHERMAN, G.D. (1953): Chemical weathering of mineral soils. *Adv. in Agron.* 5: 219-318.

LAW, W.M. (1968): Reconnaissance Soil Map of Peninsular Malaysia. Ministry of Agriculture and Cooperative, Kuala Lumpur.

LEAMY, M.L and PANTON, W.P. (1965): A Soil Survey Manual For Malayan Conditions. Soil Science Division, Ministry of Agriculture and Cooperative, Kuala Lumpur.

MEHRA, O.P. and JACKSON, M.L. (1960): Iron oxide removal from soils and clays by dithionite-citrate system with sodium bicarbonate buffer. *Clays and Clay Minerals.* 7: 317–327.

NOSSIN, J.J. (1961): Relief and coastal development in north-eastern Johore. *J. Trop. Geog.* **15**: 27–39.

NOSSIN, J.J. (1964): Beach ridges in the east coast of Malaya. *J. Trop. Geog.* **18**: 111–117.

PARAMANANTHAN, S. (1980): Draft field legend for soil survey in Peninsular Malaysia. Soil Science Division, Ministry of Agriculture and Rural Development, Kuala Lumpur.

PARAMANANTHAN, S. (1981): Simplified key to the identification of Peninsular Malaysia (In press).

PETTIJOHN, F.J. (1957): Sedimentary Rocks. New York. Harper and Row Publication.

REINECK, H. and SINGH, I.B. (1973): Depositional sedimentary Environments. New York. Springer-Verlag.

SIVAM, S.P. (1968): Radiocarbon dates in Kinta Valley. Newsletter. *Geol. Soc. Malays.* **15(1)**.

SIVAM, S.P. (1969): Quaternary alluvial deposits in North Kinta Valley, Perak. M.Sc. thesis, U.M., Kuala Lumpur.

STAUFFER, P.H. (1973): Cenozoic. In "Geology of the Malay Peninsular". Gobbett, D.J. and Hutchison, C.S. (Ed.). New York. John Wiley and Sons. pp. 143–176.

STOOPS, G. (1978): Provisional notes on micropedology. ITC., Rug., Belgium.

SYS, C. (1979): Tropical soils. II. ITC., Rug., Belgium.

TESSENS, E. and SHAMSHUDDIN, J. (1982): Characteristics related to charges in Oxisols of Peninsular Malaysia. *Pedologie* **32**: 85–106.

TJIA, H.D. (1970): Monsoon-control of the eastern shorelines of Malaya. *Bull. Geol. Soc. Malays.* **3**: 9–15.

TJIA, H.D. (1973): Geomorphology. In: Geology of the Malay Peninsula. Gobbett, D.J. and Hutchison, C.S. (Eds.). New York. John Wiley and Sons. pp. 13–24.

USDA (1975): Soil Taxonomy: A basic system of soil classification for making and interpreting soil survey. USDA Handbook No. 436. Washington.

VAN WAMBEKE, A. (1962): Criteria for classifying tropical soils by age. *J. Soil Sci.* **13**: 124–132.

YEH, C.S.K. (1968): Regional geology: West Malaysia. Brief outline of the geology of West Malaysia. *Malays. Geol. Surv. Rept.* pp. 53–67.

YIN, E.H. and SHU, Y.K. (1973): Geological Map of Peninsular Malaysia. Geological Survey Malaysia. Ipoh.

YUAN, T.L. (1959): Determination of exchangeable hydrogen by titration method. *Soil Sci.* **88**: 164–167.

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APPENDIX

PROFILE 1: NANGKA SERIES

Hor	Depth (cm)	Particle Size Analysis: Fine Earth (%)			Sand (%)					VFS % / Sand
		Clay	Silt	Sand	VFS	FS	MS	CS	VCS	
Ap	0–25	8.50	8.50	83.0	4.73	28.3	27.5	13.9	8.32	5.70
B_{21}	25–69	9.20	12.8	78.0	4.60	23.6	27.8	15.7	6.20	5.23
B_{22}	69–125	12.1	10.5	77.4	4.78	23.6	27.1	15.2	6.44	6.18

Hor	pH (1 : 1)		Ext. A	Exch. A	Al	Al.S	Fe_2O_3	O.C	N	C/N
	H_2O	KCl	meq/100 q soil			%	%	%	%	
Ap	5.7	4.4	4.70	0.48	0.43	14	0.21	1.27	0.09	14.1
B_{21}	6.0	4.2	2.88	0.24	0.14	8	0.29	0.24	0.05	4.8
B_{22}	5.3	4.2	2.66	0.90	0.90	24	0.29	0.12	0.02	6.0

Hor	Bases: Na	K	Mg	Ca	Σ Bases	B.S	CEC: NH_4OAC	NH_4Cl	App. CEC
	meq/100 g soil					%	meq/100 g soil		meq/ 100 g
A	0.08	0.06	0.17	2.36	2.67	48	5.60	2.90	65.9
B_{22}	tr	0.02	0.11	1.41	1.54	43	3.60	1.80	39.1
B_{22}	0.04	0.02	0.08	2.71	2.85	98	2.90	1.60	23.9

PROFILE 2: KG PUSU SERIES

Hor	Depth (cm)	Particle Size Analysis: Fine Earth (%) Clay	Silt	Sand	Sand (%) VFS	FS	MS	CS	VCS	VFS % / Sand
Ap	0–21	35.4	25.3	39.3	10.8	19.3	5.70	2.89	0.59	27.5
B_{21}	21–46	37.9	21.6	40.5	11.4	18.8	6.54	2.93	0.74	28.1
B_{22}	46–100	29.4	20.3	50.3	14.2	24.2	7.40	3.14	1.38	28.2

Hor	pH (1 : 1) H_2O	KCl	Ext. A (meq/100 q soil)	Exch. A	Al	Al.S %	Fe_2O_3 %	O.C %	N %	C/N
Ap	4.9	4.0	23.7	3.52	3.21	75	0.84	5.31	0.16	33.2
B_{21}	5.0	3.8	18.0	2.96	2.85	85	0.97	0.18	0.05	3.6
B_{22}	5.1	3.8	12.8	2.72	2.49	82	0.21	0.03	0.05	0.6

Hor	Bases (meq/100 g soil) Na	K	Mg	Ca	Σ Bases	B.S %	CEC (meq/100 g soil) NH_4OAC	NH_4Cl	App. CEC meq/100 g
Ap	0.04	0.12	0.32	0.57	1.05	6	18.1	6.60	51.1
B_{21}	tr	0.02	0.09	0.40	0.51	4	11.5	4.80	30.3
B_{22}	0.04	0.02	0.09	0.38	0.53	4	12.2	5.40	41.5

PROFILE 3: BT TUKU SERIES

Hor	Depth (cm)	Fine Earth (%) Clay	Silt	Sand	Particle Size Analysis: Sand (%) VFS	FS	MS	CS	VCS	VFS % / Sand
Ap	0–16	17.9	41.9	40.2	17.0	19.9	2.60	0.61	0.09	42.3
B_{21}	16–58	28.7	39.1	32.2	15.3	14.7	1.86	0.23	0.05	47.5
B_{22}	58–130	31.5	36.3	32.2	14.8	15.2	1.63	0.44	0.18	46.0

Hor	pH (1 : 1) H_2O	KCl	Ext. A	Exch. A	Al	Al.S	Fe_2O_3	O.C	N	C/N
			meq/100 q soil			%	%	%	%	
Ap	4.8	3.7	16.7	2.32	2.14	74	0.36	0.81	0.09	9.0
B_{21}	5.0	3.8	19.2	2.88	2.60	84	1.14	0.08	0.05	1.8
B_{22}	5.0	3.7	12.8	3.92	3.60	88	1.04	0.06	0.05	1.2

Hor	Bases Na	K	Mg	Ca	Σ Bases	B.S %	CEC NH_4OAC	NH_4Cl	App. CEC meq/ 100 g
	meq/100 g soil						meq/100 g soil		
Ap	0.04	0.08	0.22	0.43	0.77	5	14.3	2.70	79.9
B_{21}	0.04	0.02	0.08	0.36	0.50	5	10.9	4.80	38.0
B_{22}	tr	0.02	0.10	0.37	0.49	4	11.2	6.20	35.6

PROFILE 4: KERAYONG SERIES

Hor	Depth (cm)	Particle Size Analysis: Fine Earth (%) Clay	Silt	Sand	Sand (%) VFS	FS	MS	CS	VCS	VFS % / Sand
Ap	0–28	53.5	38.1	8.40	2.91	4.04	0.57	0.37	0.50	34.6
B_{21}	28–64	59.8	32.1	8.10	4.08	3.82	0.16	0.04	0	50.4
B_{22}	64–125	54.4	43.9	1.70	1.16	0.39	0.09	0.04	0	68.2

Hor	pH (1 : 1) H_2O	pH (1 : 1) KCl	Ext. A	Exch. A	Al	Al.S	Fe_2O_3	O.C	N	C/N
			meq/100 q soil			%	%	%	%	
Ap	5.9	4.4	17.6	0.40	0.11	2	1.77	1.74	0.05	34.8
B_{21}	5.0	3.9	17.6	4.24	3.85	83	2.29	0.24	0.04	6.0
B_{22}	5.2	3.8	11.2	5.20	4.21	86	2.29	0.09	0.04	2.3

Hor	Bases Na	K	Mg	Ca	Σ Bases	B.S	CEC NH_4OAC	CEC NH_4Cl	App. CEC
		meq/100 g soil				%	meq/100 g soil		meq/ 100 g
Ap	0.12	0.17	3.06	2.98	6.33	39	16.2	9.60	30.3
B_{21}	tr	0.21	0.16	0.40	0.80	8	10.1	10.1	16.9
B_{22}	tr	0.05	0.28	0.35	0.68	6	11.2	11.0	20.6

PROFILE 5: CHG HANGUS SERIES

Hor	Depth (cm)	Particle Size Analysis: Fine Earth (%) Clay	Silt	Sand	Sand (%) VFS	FS	MS	CS	VCS	VFS % / Sand
Ap	0–20	64.1	34.3	1.60	1.02	0.31	0.12	0.04	0.05	63.8
B_{21}	20–54	53.1	44.2	2.70	2.23	0.32	0.09	0.05	0	82.6
B_{22}	54–90	43.2	47.3	9.50	7.03	0.86	0.20	0.16	0.82	74.0

Hor	pH (1 : 1) H_2O	KCl	Ext. A (meq/100 q soil)	Exch. A (meq/100 q soil)	Al (meq/100 q soil)	Al.S %	Fe_2O_3 %	O.C %	N %	C/N
Ap	4.7	3.7	22.8	5.84	4.53	84	1.25	0.51	0.06	8.5
B_{21}	5.1	3.7	11.4	4.00	3.21	38	4.72	0.18	0.02	9.0
B_{22}	5.3	3.9	9.74	2.88	2.67	27	4.72	0.09	0.04	2.3

Hor	Bases Na	K	Mg	Ca	Σ Bases	B.S %	CEC NH_4OAC	NH_4Cl	App. CEC meq/ 100 g
	meq/100 g soil						meq/100 g soil		
Ap	0.04	0.08	0.24	0.51	0.87	5	17.9	14.4	27.9
B_{21}	0.04	0.05	4.44	0.74	6.26	35	15.2	13.2	28.6
B_{22}	0.04	0.07	6.02	0.91	7.04	49	14.4	12.0	33.3

PROFILE 6: LINTANG SERIES

Hor	Depth (cm)	Particle Size Analysis: Fine Earth (%) Clay	Silt	Sand	Sand (%) VFS	FS	MS	CS	VCS	VFS % / Sand
Ap	0–25	14.9	5.81	79.3	2.65	17.6	16.9	21.2	21.0	3.34
B_1	25–37	13.8	4.77	81.4	2.42	10.4	17.0	29.2	22.4	2.97
B_{21}	37–65	15.9	4.06	80.0	1.86	7.68	14.8	29.2	26.1	2.33
B_{22}	65–105	19.9	4.78	75.3	2.63	13.3	18.1	28.9	14.3	3.49
B_{23}	105–115	23.1	3.87	73.0	3.13	12.3	16,5	25.1	15.9	4.29

Hor	pH (1 : 1) H_2O	KCl	Ext. A	Exch. A	Al	Al.S	Fe_2O_3	O.C	N	C/N
			meq/100 q soil			%	%	%	%	
Ap	5.1	3.8	8.80	1.52	0.58	62	0.57	0.85	0.07	12.1
B_1	4.7	3.8	6.40	1.60	0.78	79	0.93	0.22	0.04	5.5
B_{21}	4.8	3.8	7.16	1.68	0.81	61	0.57	0.28	0.06	4.7
B_{22}	4.9	3.9	0.60	1.04	0.36	71	0.93	0.19	0.03	6.3
B_{23}	4.7	3.9	4.04	1.28	0.55	71	0.93	0.19	0.04	4.8

Hor	Bases Na	K	Mg	Ca	Σ Bases	B.S %	CEC NH_4OAC	NH_4Cl	App. CEC meq/ 100 g
		meq/100 g soil					meq/100 g soil		
Ap	tr	0.08	0.18	0.10	0.36	7	5.40	3.00	36.2
B_1	tr	0.03	0.08	0.10	0.21	6	3.80	2.40	27.5
B_{21}	tr	0.06	0.07	0.38	0.51	13	4.00	2.60	25.2
B_{22}	tr	tr	0.05	0.10	0.15	4	3.40	2.80	17.1
B_{23}	tr	0.01	0.04	0.18	0.23	7	3.40	3.00	14.7

PROFILE 7: SG BULOH SERIES

Hor	Depth (cm)	Particle Size Analysis: Fine Earth (%)			Sand (%)					VFS % / Sand
		Clay	Silt	Sand	VFS	FS	MS	CS	VCS	
Ap	0–43	2.20	3.77	94.0	5.25	18.0	20.6	30.8	19.4	5.59
AC_1	43–77	3.80	5.03	91.2	6.55	20.3	20.5	30.7	13.1	7.18
AC_2	77–107	3.37	4.41	92.2	7.28	23.2	19.1	25.6	17.4	7.90
C	107–150	0.71	4.48	94.8	9.10	23.5	19.1	27.2	16.5	9.60

Hor	pH (1 : 1)		Ext. A	Exch. A	Al	Al.S	Fe_2O_3	O.C	N	C/N
	H_2O	KCl	meq/100 q soil			%	%	%	%	
Ap	4.4	4.2	3.06	0.64	0.55	47	0.51	0.97	0.07	13.9
AC_1	4.7	4.6	1.32	0.32	0.15	32	0.70	0.22	0.01	22.0
AC_2	4.9	4.6	0.76	0.32	0.06	19	0.70	0.18	0.01	18.0
C	5.4	5.1	0.44	0.08	0.08	20	0.33	0.05	0.01	5.0

Hor	Bases				Σ Bases	B.S	CEC		App. CEC
	Na	K	Mg	Ca		%	NH_4OAC	NH_4Cl	meq/
	meq/100 g soil						meq/100 g soil		100 g
Ap	tr	tr	0.10	0.52	0.62	21	3.00	0.60	136.4
AC_1	tr	tr	0.08	0.24	0.32	23	1.40	0.40	36.8
AC_2	tr	tr	0.02	0.23	0.25	25	1.00	tr	29.7
C	tr	tr	0.03	0.29	0.32	53	0.60	tr	84.5

PROFILE 8: SG BULOH SERIES

Hor	Depth (cm)	Particle Size Analysis: Fine Earth (%) Clay	Silt	Sand	Sand (%) VFS	FS	MS	CS	VCS	VFS % / Sand
Ap	0–24	5.94	6.65	87.4	4.03	17.1	23.2	30.8	12.3	4.61
AC_1	24–65	8.36	4.51	87.1	3.39	14.2	19.6	34.2	15.6	3.89
AC_2	65–106	8.74	4.93	86.3	3.30	13.8	21.0	31.5	16.6	3.82
AC_3	106–115	0.26	4.02	86.7	2.98	12.0	20.6	33.0	18.0	3.44

Hor	pH (1 : 1) H_2O	pH (1 : 1) KCl	Ext. A (meq/100 q soil)	Exch. A (meq/100 q soil)	Al (meq/100 q soil)	Al.S %	Fe_2O_3 %	O.C %	N %	C/N
Ap	4.5	3.7	4.38	1.12	1.08	60	0.52	1.64	0.04	41.0
AC_1	4.8	3.9	1.76	0.80	0.68	63	0.43	0.18	0.01	18.0
AC_2	4.8	3.8	1.86	0.80	0.58	55	0.52	0.09	0.01	9.0
AC_3	4.8	3.8	1.84	1.04	0.71	56	0.52	0.08	0.01	8.0

Hor	Bases Na (meq/100 g soil)	K	Mg	Ca	Σ Bases	B.S %	CEC NH_4OAC (meq/100 g soil)	CEC NH_4Cl (meq/100 g soil)	App. CEC meq/ 100 g
Ap	tr	tr	0.08	0.64	0.72	15	4.80	1.60	80.8
AC_1	tr	tr	0.04	0.36	0.40	25	1.60	0.60	19.1
AC_2	tr	tr	0.05	0.42	0.47	34	1.40	0.80	16.0
AC_3	tr	tr	0.04	0.51	0.55	46	1.20	0.80	13.0

PROFILE 9: NANGKA SERIES

Hor	Depth (cm)	Fine Earth (%) Clay	Silt	Sand	Sand (%) VFS	FS	MS	CS	VCS	VFS % / Sand
Ap	0–22	11.7	5.81	82.5	4.64	25.8	26.7	18.3	7.14	5.62
B_{21}	22–52	14.7	3.16	82.1	3.17	16.0	22.8	27.0	13.2	3.86
B_{22}	52–99	14.7	3.52	81.8	3.21	17.8	25.5	26.1	9.06	3.92
B_{23}	99–110	13.6	4.08	82.3	2.78	17.0	26.9	26.6	9.06	3.38

Particle Size Analysis

Hor	pH (1 : 1) H_2O	KCl	Ext. A	Exch. A	Al	Al.S %	Fe_2O_3 %	O.C %	N %	C/N
			meq/100 q soil							
Ap	4.6	3.7	3.44	1.52	1.29	72	0.43	0.86	0.04	21.5
B_{21}	4.8	3.7	2.60	1.36	1.35	74	0.43	0.23	0.01	23.0
B_{22}	4.8	3.7	2.60	1.52	1.23	76	0.43	0.55	0.01	55.0
B_{23}	4.8	3.7	2.42	1.60	1.23	84	0.43	0.11	0.01	11.0

Hor	Bases Na	K	Mg	Ca	Σ Bases	B.S %	CEC NH_4OAC	NH_4Cl	App. CEC meq/ 100 g
	meq/100 g soil						meq/100 g soil		
Ap	tr	tr	0.06	0.33	0.37	11	3.60	1.20	30.8
B_{21}	tr	tr	0.04	0.43	0.47	21	2.20	1.20	15.0
B_{22}	tr	tr	0.04	0.35	0.39	20	2.00	1.20	13.6
B_{23}	tr	tr	0.04	0.20	0.24	10	2.40	2.40	17.6

PROFILE 10: SUBANG SERIES

Hor	Depth (cm)	Particle Size Analysis Fine Earth (%)			Sand (%)					VFS % Sand
		Clay	Silt	Sand	VFS	FS	MS	CS	VCS	
Ap	0–33	18.9	21.4	59.7	14.7	25.7	8.04	7.55	3.68	24.6
Aps	33–45	1.89	15.3	82.8	13.4	31.6	14.6	16.1	7.22	16.2
AC_1	45–68	4.24	15.6	80.2	16.3	31.9	13.4	12.0	6.43	20.3
AC_2	68–102	13.3	7.82	78.9	5.57	18.0	14.9	22.1	18.2	7.06
AC_3	102–145	12.5	12.0	75.5	11.7	26.8	13.4	15.2	8.35	15.5
C	145–155	6.36	4.21	89.4	2.52	14.9	18.2	28.4	25.4	2.82

Hor	pH (1 : 1)		Ext. A	Exch. A	Al	Al.S	Fe_2O_3	O.C	N	C/N
	H_2O	KCl	meq/100 q soil			%	%	%	%	
Ap	4.1	3.9	12.8	3.04	2.57	89	tr	3.60	0.17	21.2
Aps	4.4	4.0	3.20	0.88	0.59	76	tr	0.23	0.04	5.8
AC_1	4.2	3.9	3.24	0.72	0.59	69	tr	tr	0.04	0
AC_2	4.3	3.8	4.80	1.44	1.09	80	1.77	0.04	0.04	1.0
AC_3	4.2	3.8	4.80	1.04	0.84	81	2.29	0.07	0.04	1.8
C	4.5	3.7	3.27	0.96	0.61	69	0.07	0.10	0.04	2.5

Hor	Bases Na	K	Mg	Ca	Σ Bases	B.S %	CEC NH_4OAC	NH_4Cl	App. CEC meq/ 100 g
	meq/100 g soil						meq/100 g soil		
Ap	0.03	0.02	0.03	0.23	0.31	3	10.6	4.00	56.1
Aps	tr	tr	0.01	0.18	0.19	11	1.80	1.20	95.2
AC_1	0.03	tr	0.01	0.23	0.27	23	1.20	0.80	28.3
AC_2	0.03	tr	0.05	0.20	0.28	11	2.60	2.00	19.5
AC_3	tr	tr	0.03	0.17	0.20	8	2.60	1.80	20.8
C	tr	tr	0.07	0.20	0.27	17	1.60	1.50	25.2

PROFILE 11: SOGOMANA SERIES

Hor	Depth (cm)	Fine Earth (%) Clay	Silt	Sand	Particle Size Analysis Sand (%) VFS	FS	MS	CS	VCS	VFS % / Sand
Ap	0–23	45.8	46.2	8.00	0.61	0.95	1.28	2.56	2.56	7.62
B_{21t}	23–64	34.9	62.1	3.00	0	0.26	0.52	1.24	1.04	0
B_{22t}	64–102	66.6	31.4	2.00	0	0.17	0.29	0.68	0.80	0

Hor	pH (1 : 1) H_2O	KCl	Ext. A (meq/100 g soil)	Exch. A (meq/100 g soil)	Al (meq/100 g soil)	Al.S %	Fe_2O_3 %	O.C %	N %	C/N
Ap	5.3	4.1	11.2	1.44	0.89	21	0.07	1.49	0.05	29.8
B_{21t}	4.7	3.7	13.3	4.72	3.74	75	0.07	0.42	0.09	4.7
B_{22t}	4.7	3.7	14.4	4.88	4.08	83	0.07	0.34	0.06	5.7

Hor	Bases (meq/100 g soil) Na	K	Mg	Ca	Σ Bases	B.S %	CEC (meq/100 g soil) NH_4OAC	NH_4Cl	App. CEC meq/100 g
Ap	0.07	0.08	0.69	2.56	3.40	25	13.8	8.60	30.1
B_{21t}	0.08	0.08	0.23	0.87	1.25	8	15.4	15.4	44.1
B_{22t}	0.05	0.06	0.15	0.60	0.86	6	15.0	14.6	22.5

PROFILE 12: KERAYONG SERIES

Hor	Depth (cm)	Particle Size Analysis: Fine Earth (%) Clay	Silt	Sand	Sand (%) VFS	FS	MS	CS	VCS	VFS % / Sand
Ap	0–20	20.6	36.4	43.0	26.2	14.7	1.20	0.63	0.10	60.9
B_{21}	20–59	28.6	34.6	36.8	20.7	14.4	1.05	0.50	0.22	56.3
B_{22}	59–102	39.9	33.6	26.5	15.4	9.76	0.67	0.41	0.20	58.1
B_{23}	102–150	49.9	28.8	21.3	10.1	9.30	1.35	0.25	0.10	47.4

Hor	pH (1 : 1) H_2O	pH (1 : 1) KCl	Ext. A meq/100 g soil	Exch. A meq/100 g soil	Al meq/100 g soil	Al.S %	Fe_2O_3 %	O.C %	N %	C/N
Ap	4.3	3.6	15.2	3.12	2.35	72	0.57	2.45	0.20	12.3
B_{21}	4.8	3.8	8.82	3.60	2.79	89	0.86	0.94	0.11	8.5
B_{22}	4.6	3.7	13.4	4.08	3.38	92	1.36	0.33	0.11	3.0
B_{23}	4.9	3.8	15.1	4.32	3.44	91	2.47	0.25	0.07	3.6

Hor	Bases Na	K	Mg	Ca	Σ Bases	B.S %	CEC NH_4OAC	NH_4Cl	App. CEC meq/ 100 g
	meq/100 g soil						meq/100 g soil		
Ap	0.07	0.22	0.21	0.43	0.93	12	7.60	2.20	36.9
B_{21}	0.07	0.02	0.05	0.20	0.34	4	7.80	4.40	27.3
B_{22}	0.07	tr	0.05	0.19	0.31	5	6.00	4.60	15.0
B_{23}	0.07	tr	0.06	0.23	0.36	4	10.0	7.10	20.0

PROFILE 13: SG BULOH SERIES

Hor	Depth (cm)	Fine Earth (%)			Sand (%)					VFS % / Sand
		Clay	Silt	Sand	VFS	FS	MS	CS	VCS	
Ap	0–24	7.46	4.97	87.6	2.95	21.2	31.1	27.5	4.64	3.37
AC_1	24–75	11.1	2.54	86.4	2.75	16.5	26.7	29.6	10.7	3.18
AC_2	75–123	11.9	2.92	85.2	3.65	17.9	27.3	26.5	9.65	4.28
AC_3	123–133	9.19	2.11	88.7	1.76	10.5	20.6	32.5	24.0	1.98

Particle Size Analysis

Hor	pH (1 : 1) H_2O	pH (1 : 1) KCl	Ext. A (meq/100 g soil)	Exch. A (meq/100 g soil)	Al (meq/100 g soil)	Al.S %	Fe_2O_3 %	O.C %	N %	C/N
Ap	4.8	4.1	6.30	1.68	1.40	73	0.36	1.47	0.14	10.5
AC_1	5.0	4.3	5.54	1.52	1.12	80	0.29	0.73	0.04	18.3
AC_2	4.9	4.3	4.60	1.20	0.84	79	0.29	0.27	0.06	4.5
AC_3	4.7	4.2	4.96	1.36	0.89	77	0.36	0.13	0.04	3.3

Hor	Bases Na	Bases K	Bases Mg	Bases Ca	Σ Bases	B.S %	CEC NH_4OAC	CEC NH_4Cl	App. CEC meq/ 100 g
	meq/100 g soil						meq/100 g soil		
Ap	0.07	tr	0.04	0.41	0.52	9	6.00	2.80	84.4
AC_1	0.07	tr	0.01	0.20	0.28	7	3.80	2.20	34.2
AC_2	0.07	tr	0.01	0.15	0.23	8	2.80	2.00	23.5
AC_3	0.07	tr	0.02	0.17	0.26	13	2.00	1.60	21.8

PROFILE 14: RASAU SERIES

Hor	Depth (cm)	Particle Size Analysis								VFS % / Sand
		Fine Earth (%)			Sand (%)					
		Clay	Silt	Sand	VFS	FS	MS	CS	VCS	
A_1	0–10	16.7	28.7	54.6	15.5	26.7	9.44	2.75	0.27	28.4
B_{21}	10–33	19.1	29.7	51.2	16.9	25.1	7.15	2.00	0.60	33.0
B_{22}	33–85	17.1	34.1	48.8	16.2	23.5	6.58	1.99	0.52	33.2
B_{23}	85–118	21.9	30.9	47.2	16.0	21.3	6.62	2.42	0.89	33.9
B_{24}	118–128	21.8	28.6	49.6	16.4	24.4	6.52	2.10	0.67	33.1

Hor	pH (1 : 1)		Ext. A	Exch. A	Al	Al.S	Fe_2O_3	O.C	N	C/N
	H_2O	KCl	meq/100 g soil			%	%	%	%	
A_1	4.2	3.5	16.6	4.16	3.13	86	tr	3.95	0.22	18.0
B_{21}	4.4	3.9	5.50	2.88	2.51	86	tr	1.33	0.10	13.3
B_{22}	4.6	4.0	4.24	2.64	1.98	84	tr	0.54	0.07	7.7
B_{23}	4.7	4.0	3.98	2.72	2.21	86	tr	0.23	0.06	3.8
B_{24}	4.8	3.9	4.18	2.32	1.73	79	tr	0.14	0.06	2.3

Hor	Bases				Σ Bases	B.S	CEC		App. CEC
	Na	K	Mg	Ca		%	NH_4OAC	NH_4Cl	meq/
	meq/100 g soil						meq/100 g soil		100 g
A_1	0.12	0.18	0.04 0.04	0.17	0.51	4	11.6	6.00	69.5
B_{21}	0.07	0.04	0.04	0.25	0.40	7	5.80	5.00	30.4
B_{22}	0.10	0.02	0.04	0.23	0.39	8	4.60	3.80	26.9
B_{23}	0.10	tr	0.03	0.23	0.36	9	4.20	4.00	19.2
B_{24}	0.10	tr	0.03	0.34	0.47	12	4.00	3.60	18.3

PROFILE 15: NAPAI SERIES

Hor	Depth (cm)	Fine Earth (%)			Sand (%)					VFS % / Sand
		Clay	Silt	Sand	VFS	FS	MS	CS	VCS	
A_{11}	0–13	12.2	19.6	68.2	23.8	35.1	5.39	0.98	2.93	34.9
A_{12cn}	13–30	16.5	17.8	65.7	17.3	26.4	4.76	1.18	16.1	26.3
B_{21tcn}	30–55	39.6	10.8	49.6	9.37	11.9	2.42	1.84	24.0	18.9
B_{22tcn}	55–90	40.9	8.91	50.2	7.48	9.37	2.58	3.58	27.1	14.9
B_{23tcn}	90–100	53.1	14.6	32.3	12.4	9.29	1.60	1.24	7.84	38.4

Particle Size Analysis

Hor	pH (1 : 1) H_2O	pH (1 : 1) KCl	Ext. A	Exch. A	Al	Al.S	Fe_2O_3	O.C	N	C/N
			meq/100 g soil			%	%	%	%	
A_{11}	4.4	3.7	5.02	1.92	1.17	53	1.25	1.68	0.11	15.3
A_{12cn}	4.6	3.8	5.00	2.24	1.56	85	2.28	0.50	0.07	7.1
B_{21tcn}	4.7	3.8	7.24	4.00	3.34	90	3.96	0.46	0.07	6.6
B_{22tcn}	4.7	3.9	7.34	3.60	3.05	89	6.10	0.31	0.07	4.4
B_{23tcn}	4.9	3.9	6.96	4.24	3.36	86	4.89	0.32	0.06	5.3

Hor	Bases Na	K	Mg	Ca	Σ Bases	B.S %	CEC NH_4OAC	CEC NH_4Cl	App. CEC meq/ 100 g
	meq/100 g soil						meq/100 g soil		
A_{11}	tr	0.10	0.38	0.54	1.02	20	5.20	2.80	42.6
A_{12cn}	tr	0.09	0.11	0.07	0.27	6	4.88	3.36	29.6
B_{21tcn}	tr	0.08	0.09	0.21	0.38	8	4.80	3.52	12.1
B_{22tcn}	tr	0.09	0.08	0.20	0.37	7	5.44	5.20	13.3
B_{23tcn}	0.02	0.09	0.11	0.33	0.55	11	4.94	4.80	9.30

PROFILE 16: CHUPING SERIES

Hor	Depth (cm)	Particle Size Analysis: Fine Earth (%) Clay	Silt	Sand	Sand (%) VFS	FS	MS	CS	VCS	VFS % / Sand
A_1	0–14	8.36	38.9	52.7	27.8	19.0	4.13	1.46	0.67	52.8
B_{21t}	14–35	10.7	32.5	56.8	23.4	22.1	6.28	3.12	1.74	41.2
B_{22tcn}	35–63	26.5	24.8	48.7	13.5	13.3	5.09	3.93	12.8	27.7
$11B_3$	63–73	58.5	23.8	17.7	8.57	4.50	1.63	1.79	1.36	48.5
C	73+									

Hor	pH (1 : 1) H_2O	KCl	Ext. A	Exch. A	Al	Al.S	Fe_2O_3	O.C	N	C/N
			meq/100 g soil			%	%	%	%	
A_1	5.3	4.1	8.22	1.20	0.42	20	0.88	0.60	0.07	8.6
B_{21t}	5.3	3.9	9.22	2.00	1.06	52	1.72	0.52	0.06	8.7
B_{22tcn}	5.6	3.8	11.2	3.28	2.61	51	4.05	0.26	0.06	4.3
$11B_3$	7.4	5.8	0.86	0.24	0	0	5.26	tr	0.06	0

Hor	Bases Na	K	Mg	Ca	Σ Bases	B.S %	CEC NH_4OAC	NH_4Cl	App. CEC meq/100 g
	meq/100 g soil						meq/100 g soil		
A_1	tr	0.08	0.55	1.01	1.64	34	4.80	2.88	57.4
B_{21t}	tr	0.08	0.55	1.01	1.64	34	4.80	2.88	57.4
B_{21t}	tr	0.05	0.47	0.45	0.97	25	3.84	3.68	35.9
B_{22tcn}	0.04	0.09	1.39	0.95	2.47	18	13.4	12.0	50.6
$11B_3$	0.54	0.10	11.8	8.73	21.2	100	25.2	21.2	43.1

PROFILE 17: AWANG SERIES

Hor	Depth (cm)	Fine Earth (%)			Sand (%)					VFS % / Sand
		Clay	Silt	Sand	VFS	FS	MS	CS	VCS	
Ap	9–18	4.22	8.03	87.7	3.46	12.3	20.8	29.6	21.4	3.95
A_3	18–52	9.48	10.4	80.1	4.76	14.0	17.0	22.7	21.3	5.94
B_2	52–83	23.5	9.95	66.5	3.67	9.31	11.9	18.7	22.9	5.53
B_3/BC	83–93	25.2	7.79	77.0	1.97	6.06	8.80	18.3	31.7	2.56

Particle Size Analysis

Hor	pH (1 : 1)		Ext. A	Exch. A	Al	Al.S	Fe_2O_3	O.C	N	C/N
	H_2O	KCl	meq/100 g soil			%	%	%	%	
Ap	5.2	4.1	1.84	0.80	0.11	17	0.13	0.42	0.06	7.0
A_3	5.1	4.0	1.42	1.04	0.33	38	0.13	0.26	0.03	8.7
B_2	4.9	3.8	2.30	2.40	1.50	73	0.13	0.10	0.04	2.5
B_3/BC	4.9	3.8	3.32	2.16	1.17	65	0.50	0.03	0.04	0.8

Hor	Bases				Σ Bases	B.S	CEC		App. CEC
	Na	K	Mg	Ca		%	NH_4OAC	NH_4Cl	meq/
	meq/100 g soil						meq/100 g soil		100 g
Ap	tr	0.04	0.10	0.39	0.53	76	2.02	2.00	47.9
A_3	tr	0.05	0.10	0.40	0.55	37	1.50	1.40	15.8
B_2	tr	0.07	0.10	0.38	0.55	23	2.40	2.35	10.2
B_3/BC	tr	0.05	0.11	0.47	0.63	18	3.50	3.40	13.9

PROFILE 18: HOLYROOD SERIES

Hor	Depth (cm)	Particle Size Analysis: Fine Earth (%) Clay	Silt	Sand	Sand (%) VFS	FS	MS	CS	VCS	VFS % / Sand
Ap	0–18	21.2	10.9	67.9	6.30	18.7	20.4	17.1	5.25	9.28
B_{21t}	18–35	28.6	8.92	62.5	5.00	13.4	14.7	14.0	11.2	8.00
B_{22t}	35–70	31.7	8.45	59.8	3.90	10.3	12.7	18.3	14.3	6.52
B_{23t}	70–90	34.6	8.62	56.8	4.04	10.7	11.6	15.7	14.7	7.11

Hor	pH (1 : 1) H_2O	KCl	Ext. A	Exch. A	Al	Al.S	Fe_2O_3	O.C	N	C/N
			meq/100 g soil			%	%	%	%	
Ap	4.4	3.7	6.32	1.92	0.94	53	0.88	1.92	0.14	13.7
B_{21t}	4.8	3.9	5.08	2.32	1.39	81	1.25	0.54	0.07	7.7
B_{22t}	4.7	3.8	5.14	2.48	1.45	83	1.53	0.28	0.04	7.0
B_{23t}	4.5	3.8	4.78	2.56	1.50	63	1.44	0.15	0.04	3.8

Hor	Bases Na	K	Mg	Ca	Σ Bases	B.S	CEC NH_4OAC	NH_4Cl	App. CEC meq/ 100 g
	meq/100 g soil					%	meq/100 g soil		
Ap	tr	0.10	0.03	0.72	0.85	12	7.04	3.92	33.2
B_{21t}	tr	0.04	0.06	0.22	0.32	6	5.40	4.00	18.9
B_{22t}	tr	0.03	0.06	0.20	0.29	6	4.96	4.24	15.6
B_{23t}	tr	0.12	0.34	0.41	0.87	21	4.08	3.76	11.8